OCR
Oxford Cambridge and RSA

OCR Level 3 Cambridge Technicals in Applied Science

Unit 3 Scientific analysis and reporting

Sample Assessment Material

Date – Morning/Afternoon

Time Allowed: 2 hours

You must have:
- Ruler

You may use:
- A scientific calculator

Do not use:
- None

* 800000001 *

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.
- The Periodic Table is printed on the back page.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **21** pages.

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Answer **all** questions.

1 Keys can be used for the identification of living organisms.

Table 1.1 below shows the characteristics of common invertebrates taken from a woodland.

(a) Use Table **1.1** to complete the blank spaces in the key in **Fig. 1.** Some of the key has already been completed.

Table 1.1

Woodland invertebrate	Number of Legs	Shell	Segments	Number of body parts	Number of legs per segment
snail	0	Yes			
worm	0	No	Yes		
slug	0	No	No		
beetle	6				
earwig	6				
weevil	6				
harvestman	8			1	
spider	8			2	
woodlouse	14				
centipede	>14				2
millipede	>14				4

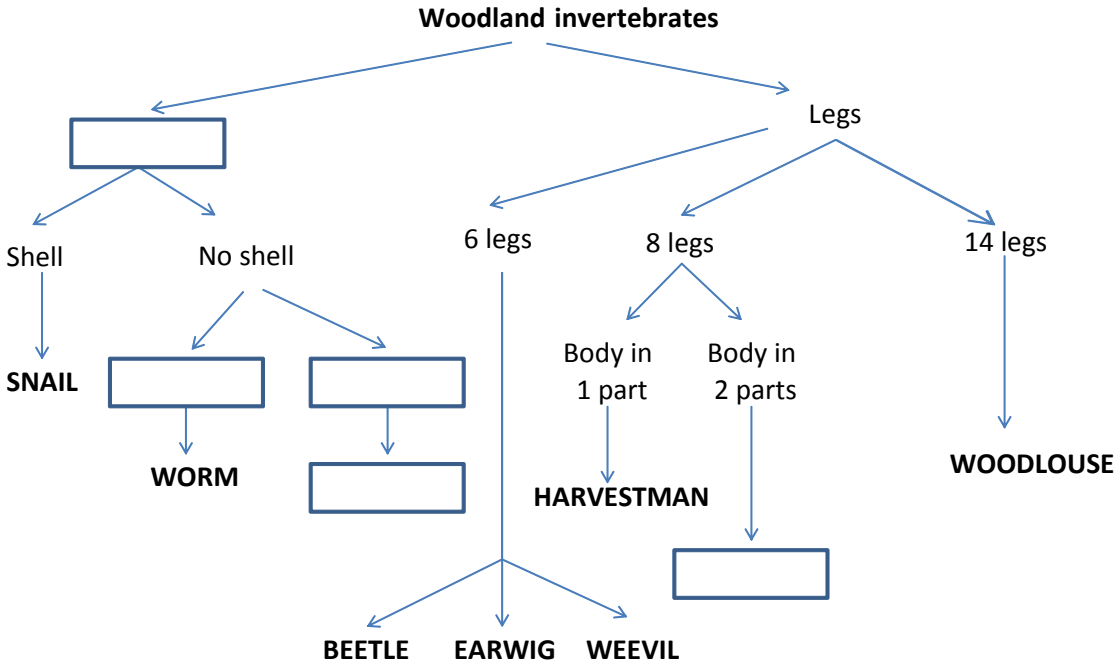

Fig. 1

[5]

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(b) An organism with 8 legs is found in the woodland. Identify which organism it might be using the identification key in **Fig. 1**.

What further information is needed to confirm an identification?

.....

.....**[2]**

(c) The woodland also has a number of invertebrates with more than 14 legs. Centipedes have 1 pair of legs per segment and millipedes have 2 pairs of legs per segment.

In the box below, adapt the **relevant** part of the key in **Fig. 1** to include these two invertebrates.

[3]

[Turn over]

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2

(a) Explain the terms ‘accuracy’ and ‘precision’ in measurements.

Accuracy.....

Precision.....**[2]**

(b)

(i) The degree of accuracy of a measuring instrument is half a unit each side of the unit of measure.

The thermometer in **Fig. 2** measures in 1°C increments.

What temperature reading is being recorded to the nearest °C?

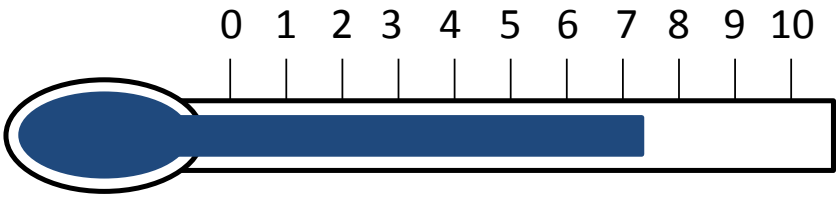

Fig. 2

……..°C **[1]**

(ii) What reading would be recorded if this thermometer now measures in 2°C increments (0°C, 2°C, 4°C, 6°C, 8°C and 10°C)?

……°C **[1]**

(iii) What is the limitation of using a thermometer that measures in 2°C increments compared with one that measures in 1°C increments?

.....

.....**[1]**

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(c) Temperature measurements are recorded in a laboratory experiment. The results are shown in **Table 2.1**.

Table 2.1

Time (s)	0	10	20	30	40	50	60	70	80	90	100
Temperature (°C)	21	24	35	36	34	40	45	44	42	36	33

(i) Specify the interval .....**[1]**

(ii) Define the range of the temperature.....**[2]**

(d) Give two reasons why it is important to use calibrated measuring instruments.

…….....

…….....

…….....

…….....**[2]**

3

(a) Express the following figures in standard form:

(i) 15 000 000 ……**[1]**

(ii) 0.000453 ……**[1]**

(iii) 1/8 ……**[1]**

(b) Express the following to 2 decimal places:

(i) 2.6470588 ……**[1]**

(ii) $\sqrt{5}$ ……**[1]**

(c) Calculate the value of X in the following equation:

$$X = 35 - 5(2 + 2^2)$$

Show your working.

X= ……**[2]**

[Turn over]

(d) A straight sided laboratory beaker is shown in **Fig 3**.

Calculate the open surface area of liquid in the beaker to **zero decimal places**.

Show your working.

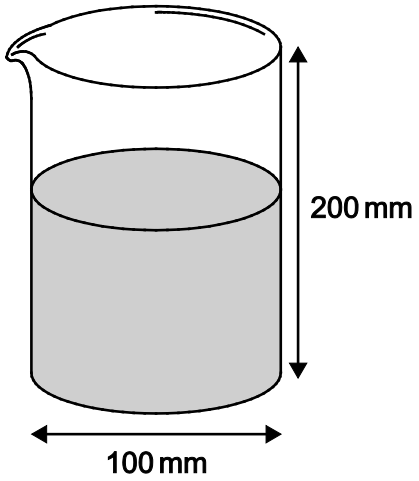

Fig. 3

.....**[3]**

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4 A research scientist carries out a small-scale investigation of the diastolic blood pressure of 20 patients.

The results (mm Hg) are shown below:

Table 4.1

Diastolic blood pressure (mm Hg)
70
72
79
93
100
85
59
105
104
72
72
85
84
75
74
99
98
104
83
76

(a) Determine the mode.

…….....**[1]**

(b) Calculate the median.

…….....**[1]**

(c) Calculate the mean. Show your working.

Mean = ..…….. **[2]**

[Turn over]

(d) The data are thought to be representative of the human population.

Use the formula below to calculate the standard deviation to **2 decimal places**.

$$\text{standard deviation } s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

N is the number of patients in the sample.

x_i is the sampled value of diastolic blood pressure.

$\overline{x}$ is the mean value of diastolic blood pressure.

Use **Table 4.2** to help you with your working.

Table 4.2

Diastolic blood pressure (mm Hg)		
70		
72		
79		
93		
100		
85		
59		
105		
104		
72		
72		
85		
84		
75		
74		
99		
98		
104		
83		
76		

.....

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.....

.....

.....Standard deviation =.....**[6]**

5 **Table 5.1** shows the biodiversity of plant species per m^2 near a motorway.

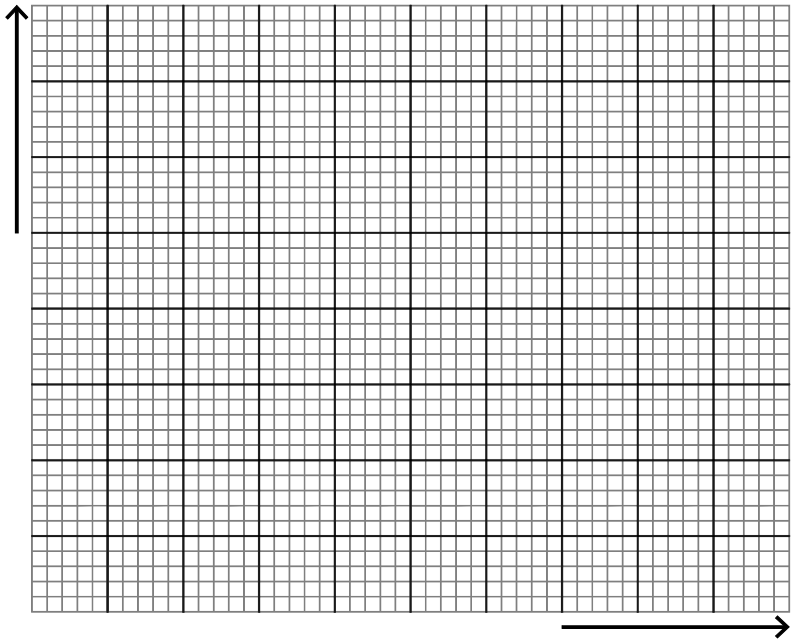
The number of plant species was recorded at different distances from the edge of the motorway. Eight different sites were investigated.

Table 5.1

Site	1	2	3	4	5	6	7	8
Distance from motorway (m)	50	100	150	200	250	300	350	450
Number of plant species	5	10	11	15	20	25	35	35

(a) Plot a graph of number of plant species versus distance from motorway.

Draw a line of 'best fit' on the graph.



[3]

(b) Interpolate to estimate the number of plant species 400 m from the motorway.

…….....**[1]**

(c) Extrapolate to suggest the number of plant species 500 m from the motorway.

…….....**[1]**

(d) The graph suggests that data from one of the sites is inconsistent. Identify which site and give a reason why you consider this to be the case.

…….....

…….....**[2]**

[Turn over]

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(e) The equation used to represent a straight line of best fit on a graph is:

$$y = mx + C$$

Where m = the gradient of the line and C = a constant.

Rewrite the equation, substituting the values in the equation to represent the relationship between the number of plant species and the distance from the motorway.

[3]

6 **Fig. 6.1** shows a graph of the results of a laboratory experiment in which the volume of a gas increases as it is heated.

Charles' Law states that for a fixed mass of gas at constant pressure, the volume is directly proportional to the temperature.

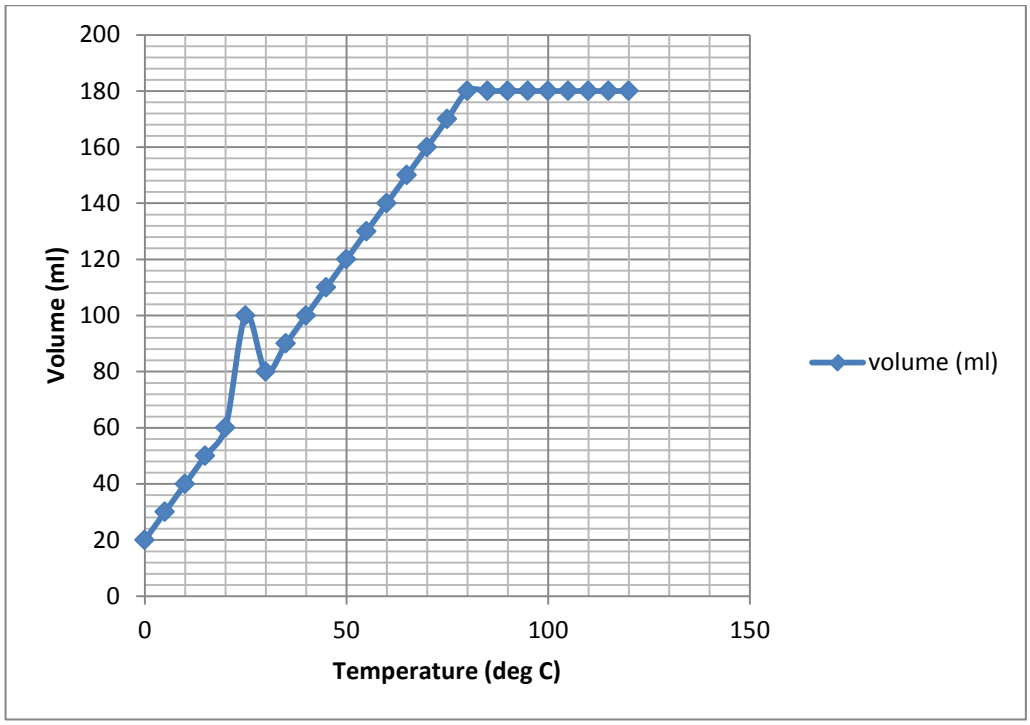

Fig. 6.1

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A graphical representation of Charles' Law found from textbooks and the Internet is shown in **Fig. 6.2**:

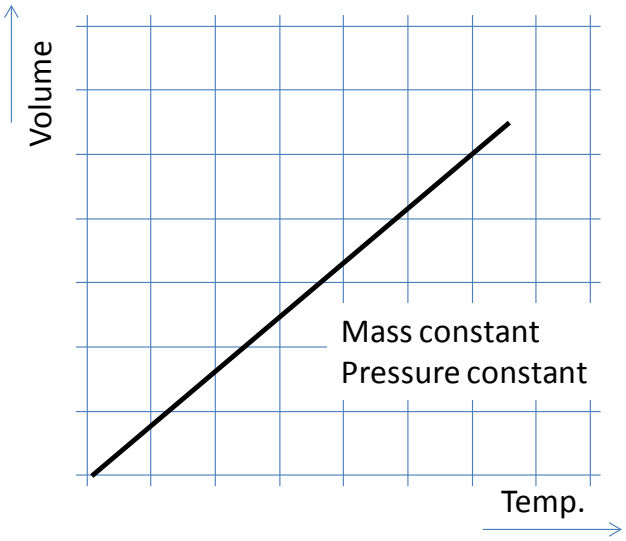

Fig. 6.2

(a) Identify the sources of primary and secondary data.

Primary data .....

Secondary data .....**[2]**

(b) By comparing Fig 6.1 and Fig 6.2 state whether the experiment can be considered to obey Charles' Law.

Justify your conclusion.

…….....

…….....

…….....

…….....

…….....

…….....**[3]**

[Turn over]

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(c) If the experiment could be repeated, suggest additional data that could be collected in order to achieve a more secure conclusion and which data might be ignored.

…….....

……..…

…….....

……..…

……..…

……..…**[2]**

(d) Suggest possible sources and causes of error in the original experimental data.

…….....

……..…

……..…**[3]**

7 Alexia is an environmental scientist. She is analysing samples of seawater collected from rock pools.

She titrates the seawater to find the concentration of salt (salinity) in the samples.

She uses a technique used to estimate chloride ions. The solutions she uses are:

- silver nitrate solution (0.1 mol dm^{-3}) and
- potassium chromate solution (0.25 mol dm^{-3})

(a) **(i)** Outline the scientific principles involved in the titration.

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.....**[4]**

(ii) Write ionic equations for the chemical reactions involved.

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.....**[4]**

(iii) What assumption is made when carrying out this titration?

.....**[1]**

(b) The average volume of the silver nitrate solution needed to neutralise 25 cm^3 of the seawater sample was 14.1 cm^3.

Calculate the concentration of **salt** in the conical flask, in g dm^{-3}.

Concentration of salt…….. g dm^{-3}

[6]

[Turn over]

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8 Many breakfast cereals are fortified with iron.

A food quality control technician is analysing samples of a breakfast cereal using ammonium thiocyanate.

(a) Samples of the breakfast cereal samples are first crushed, and the powder dissolved in concentrated sulfuric acid.

(i) Potassium manganate(VII) (potassium permanganate) solution is added to the extract until the purple colour persists for several seconds.

Explain why potassium manganate(VII) is used.

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.....**[3]**

(ii) Explain why ammonium thiocyanate can be used **quantitatively** to determine the concentration of iron(III) in the extract.

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.....**[3]**

(b) The technician prepares a series of standards of ammonium iron(III) sulfate (ferric ammonium sulfate), $FeNH_4(SO_4)_2.12H_2O$.

(i) Calculate the mass of ammonium iron(III) sulfate required to produce 1 dm^3 of a stock solution containing 20 mg dm^{-3} of **iron**.

(molar mass of ammonium iron(III) sulfate = 482.20 g mol^{-1}; iron = 55.85 g mol^{-1})

Show your working.

mass of ammonium iron(III) sulfate = …….. mg

[2]

[Turn over]

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(ii) The technician measured the absorbance of a series of iron(III) standard solutions on the addition of ammonium thiocyanate.

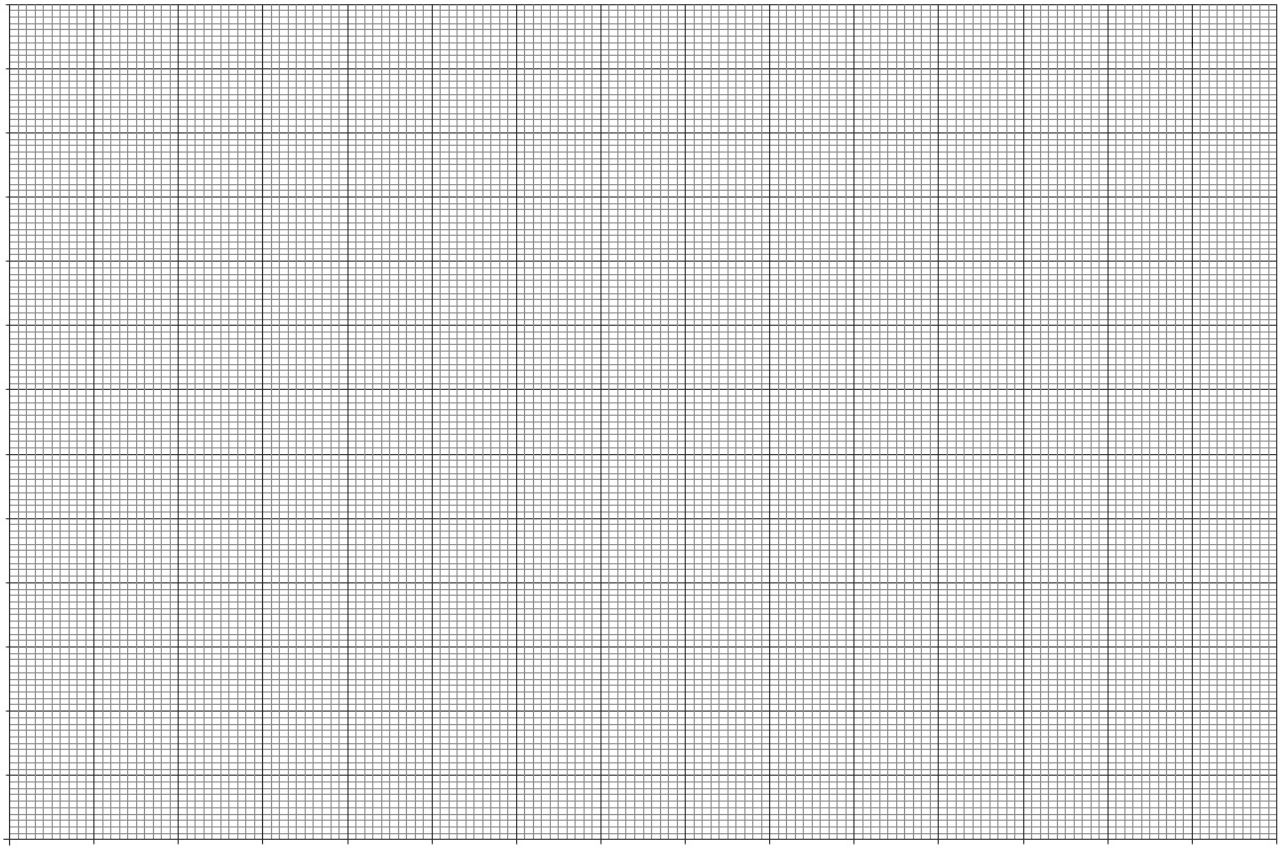
The readings are shown in **Table 8.1**:

Table 8.1

Concentration of iron (mg dm^{-3})	Absorbance
0.0	0.000
2.0	0.090
4.0	0.180
6.0	0.270
8.0	0.355
10.0	0.445
12.0	0.535
14.0	0.620

Plot a calibration graph below.

[4]



(iii) What is the concentration of iron in a sample giving an absorbance of 0.405?

…… mg dm^{-3}

[1]

9 Two learners completed laboratory reports on chromatographic analysis of ink samples. The first six steps of each report are reproduced in **Table 9.1**.

Table 9.1

Method 1	**Method 2**
Method: 1 Carry out a Risk Assessment. 2 Collect the chromatography paper. The paper should have 3 sections on it. 3 From the very bottom of the chromatography paper, measure up 10 mm and draw a line across the sections. 4 Use the suspects' pens and the crime scene ink to put a spot of each ink sample in the middle of each section of the chromatography paper on the line you have just drawn. Put Suspect A's pen ink on one section, B on the next one, and the crime scene ink on the last section. 5 Measure 80 mm from the previous line you have drawn and draw another one. This will be the line you allow the solvent front to travel to. 6 Collect the chromatography tank and fill it up so that it has about 10 mm of the solvent (70% ethanol – ethanol, 140 cm^3; water, 60 cm^3) from the base of the tank.	***Materials and methods*** 1 A pencil line was ruled on each of the thin-layer chromatography (silica gel, 230-400 mesh particle size) plates, 25 mm from the bottom. 2 I made up the solvent system (butan-1-ol, ethanol, ammonia solution, 2 mol dm^{-3} – 60:20:20; see Parkes, *et al* [2016]) and poured this into the chromatography tank. 3 I put the cover on the tank and left it undisturbed in the fume cupboard so the tank became saturated with the solvent vapour. 4 Three samples were available for analysis: sample extracted from Suspect A's pen, sample from Suspect B's pen; sample extracted from Crime Scene writing. 5 Using a micropipette, I placed a small spot of each ink on the origin of each plate. For the ink from the crime scene, I built up each spot by adding a drop, letting if evaporate, and then adding another, etc. This was because this ink wasn't very concentrated. 6 The spots were allowed to dry thoroughly. The TLC plates were then placed in the solvent in the tank.

[Turn over]

(a) Compare the scientific **methods** used in terms of the effective separation of dyes in the samples. Justify your answers.

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.....**[4]**

(b) Discuss the quality of the reports, based on:

(i) Level of **scientific detail.**

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.....**[4]**

(ii) Style of the reports.

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.....**[4]**

END OF QUESTION PAPER

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SPECIMEN

Sample Assessment Material

CAMBRIDGE TECHNICALS IN APPLIED SCIENCE
Unit 3 – Scientific analysis and reporting

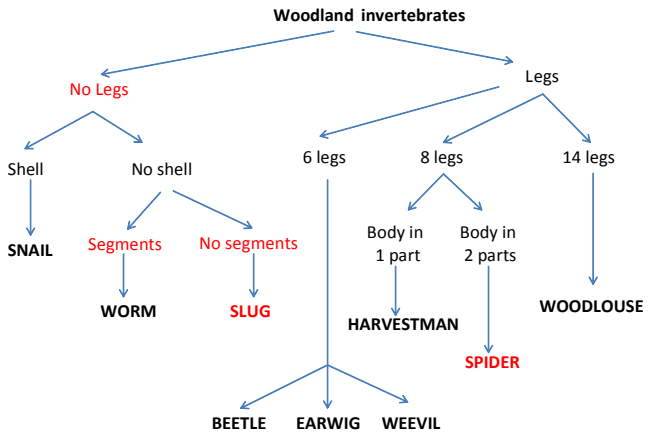
MARK SCHEME

Duration: 2 hours

MAXIMUM MARK 90

SPECIMEN

Version: 2 **Date:** 25/02/2016

Question			Answer	Marks	Guidance
1	(a)			5	1 mark for each correctly identified item in the chart (shown in red)
	(b)		Harvestman <u>OR</u> Spider Need to see how many body parts it has – 1 or 2	1 1	1 mark for identification of both possibilities 1 mark for deducing what is required for further investigation

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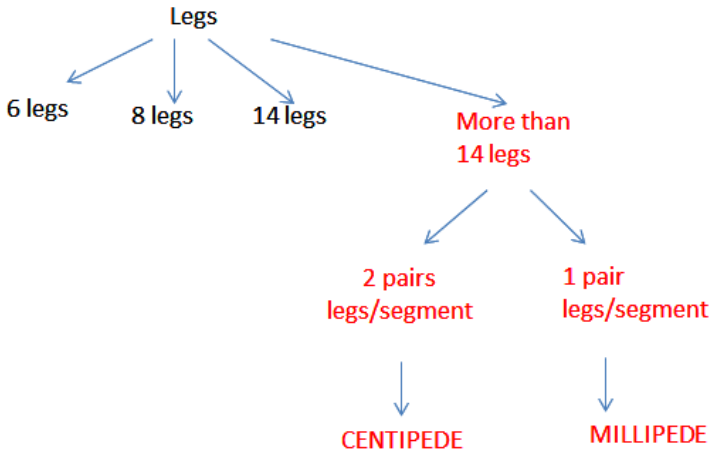
Question			Answer	Marks	Guidance
	(c)			3	More than 14 legs branch = 1 mark 2 branches (2 pairs of legs per segment and 1 pair of legs per segment branch) = 1 mark Adding centipede and millipede = 1 mark

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Question			Answer	Marks	Guidance
2	**(a)**		Accuracy: is how close a measured value is to the actual (true) value; Precision: is how close measurements are to one another;	1 1	
	(b)	**(i)**	7(°C);	1	
		(ii)	8(°C);	1	
		(iii)	The thermometer that reads in 2°C increments is not as accurate as the thermometer that reads in 1°C increments;	1	OWTTE
	(c)	**(i)**	The interval is 10 seconds;	1	
		(ii)	Range is difference between highest and lowest reading: 21- 45°C;	2	Award 1 mark for correct bottom and correct top values **Ignore** 24°C
	(d)		Accuracy of results; Eliminates systematic error / source of error;	2	**Accept** repeatability of results

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Question			Answer	Marks	Guidance
3	(a)	(i)	15 000 000 = 1.5 x 10^{7};	1	
		(ii)	0.000435 = 4.35 x 10^{-4};	1	
		(iii)	1/8 = 0.125 = 1.25 x 10^{-1};	1	
	(b)	(i)	2.6470588 = 2.65;	1	
		(ii)	$\sqrt{5}$ = 2.23606 = 2.24;	1	
	(c)		Solve using BODMAS: X = 35 – 5(2 + 4) X = 35 – 5(6);	1	
			X = 35 – 30 = 5;	1	
	(d)		Surface area is area of a circle:		
			Recall/use formula Area of Circle = π r^2;	1	
			Area = π 50^2 = rounded to 7854;	1	**Ignore** 7853.98
			mm^2;	1	
4		(a)	72 (most common number);	1	
		(b)	83.5 (as there are an even amount of numbers);	1	

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<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td></td><td>(c)</td><td>Mean = (sum of blood pressures) / number in sample /
= 1689/20;
= 84.45;</td><td>1
1</td><td></td></tr>
<tr><td></td><td></td><td>(d)</td><td>[Level 0] Candidate includes fewer than two valid points.
(0 marks)

[Level 1] Candidate shows a basic understanding of the stages of the calculation, including at least two valid points but with little or no explanation. With little evidence of a logical order.
(1 – 2 marks)

[Level 2] Candidate shows an understanding of the stages of the calculation, including at least four valid points. The explanation follows some logical order.
(3 – 4 marks)

[Level 3] Candidate shows a high level of understanding of the calculation with a limited number of errors, including at least six valid points. The explanation follows a clear logical order.
(5 - 6 marks)</td><td>6</td><td>Valid points:

Relating to the table:

<table>
<tr><th>BP reading</th><th>Xi - X(bar)</th><th>Xi- X(bar) squared</th></tr>
<tr><td>70</td><td>-14.45</td><td>208.8025</td></tr>
<tr><td>72</td><td>-12.45</td><td>155.0025</td></tr>
<tr><td>79</td><td>-5.45</td><td>29.7025</td></tr>
<tr><td>93</td><td>8.55</td><td>73.1025</td></tr>
<tr><td>100</td><td>15.55</td><td>241.8025</td></tr>
<tr><td>85</td><td>0.55</td><td>0.3025</td></tr>
<tr><td>59</td><td>-25.45</td><td>647.7025</td></tr>
<tr><td>105</td><td>20.55</td><td>422.3025</td></tr>
<tr><td>104</td><td>19.55</td><td>382.2025</td></tr>
<tr><td>72</td><td>-12.45</td><td>155.0025</td></tr>
<tr><td>72</td><td>-12.45</td><td>155.0025</td></tr>
<tr><td>85</td><td>0.55</td><td>0.3025</td></tr>
<tr><td>84</td><td>-0.45</td><td>0.2025</td></tr>
<tr><td>75</td><td>-9.45</td><td>89.3025</td></tr>
<tr><td>74</td><td>-10.45</td><td>109.2025</td></tr>
<tr><td>99</td><td>14.55</td><td>211.7025</td></tr>
<tr><td>98</td><td>13.55</td><td>183.6025</td></tr>
<tr><td>104</td><td>19.55</td><td>382.2025</td></tr>
<tr><td>83</td><td>-1.45</td><td>2.1025</td></tr>
<tr><td>76</td><td>-8.45</td><td>71.4025</td></tr>
<tr><td>Square of differences</td><td></td><td>3520.95</td></tr>
</table></td></tr>
</table>

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Question			Answer	Marks	Guidance
					Relating to the calculation: Note: for sample data $N = N-1$ i.e. 19 Variance σ^2 = average or the squared differences from the mean = 3520.95 / 19 Variance σ^2 = 185.31 Standard Deviation $s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$ Standard Deviation = √ variance =√ 185.31 = 13.61 mm Hg

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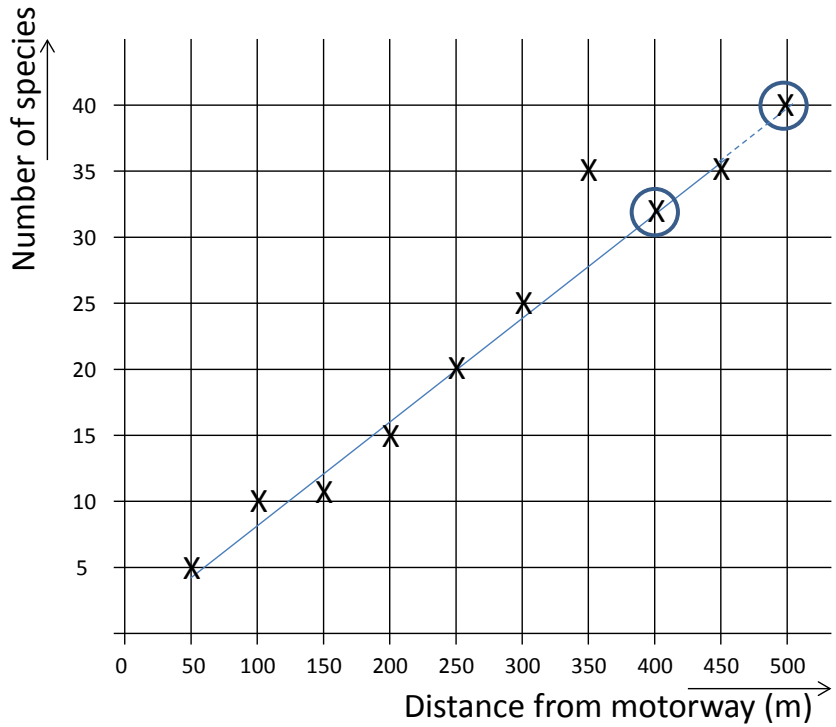
Question			Answer	Marks	Guidance
5		(a)		1 1 1	1 mark for correctly labelled axes 1 mark for accurately plotting values 1 mark for drawing straight line
		(b)	32;	1	**Accept** 30 - 34
		(c)	40;	1	**Accept** 38 - 42
		(d)	Site 7; This is because the value at site 7 is far away from the straight line – with a value of ~ 27 plant species expected;	1 1	 ECF = max 1

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Question			Answer	Marks	Guidance

5		(e)	m = eg. 20/250 = 0.08;
			
			C = y – mx;
			
			Completion of the correct values;
			
			Equation of a straight line is y = mx + C;
			
			In this case, assuming the straight line goes through the origin (0,0) and so C = 0;
			
			y = mx where m is the slope of the line
			
			Use a suitable point on graph to determine gradient (say 250, 20)
			
			m = 20/250 = 0.08
			y = 0.08 x;
				1
				
				1
				
				1	

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Question			Answer	Marks	Guidance
6		(a)	Primary data: the laboratory experiment; Secondary data: information regarding Charles' Law from textbooks and the internet;	1 1	
		(b)	**YES** The results from the experiment **can** be considered to follow Charles' Law; Justification: • Shape of graph is approximately a straight line comparable to Charles' Law; • Volume is increasing linearly with temperature; OR **NO** The results from the experiment **cannot** be considered to follow Charles' Law; Justification: • The straight line is only linear up to 80°C; • It flattens out for all points from 80 °C onwards;	 1 2 OR 1 2	

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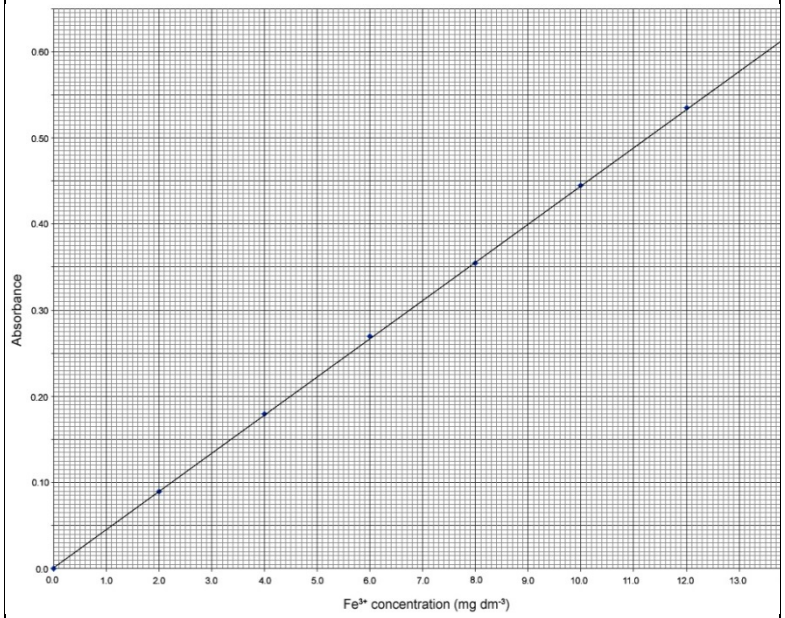
Question			Answer	Marks	Guidance
		(c)	Anomaly in data at 25 °C is most likely an outlier and can safely be ignored; Data from 80 °C onwards needs further investigation as it flattens out;	1 1	
		(d)	Possible sources of error include: • Human error in performing experiment • Results not correctly noted • Use of un-calibrated equipment • Use of faulty equipment • Not keeping pressure of gas constant • Not keeping mass of gas constant	1 1 1	Award 1 mark human-generated errors Award 1 mark for equipment-related faults Award 1 mark for errors related to pressure or mass of gas
7	(a)	(i)	*Any four from:* Chloride (ion) concentration gives an estimate (or wtte) of the salt concentration; Silver ions/nitrate/react with chloride; To form white precipitate of silver nitrate; When all chloride ions have reacted; Silver ions then react with chromate ions to form silver chromate; Reading recorded at the first appearance of red-brown colour.	4	
		(ii)	$Ag^+ + Cl^- \rightarrow AgCl$ $2Ag + CrO_4^{2-} \rightarrow Ag_2CrO_4$	4	One mark for reactants; one mark for products for each equation.

Question			Answer	Marks	Guidance
		(iii)	No bromide/Br^-/no other halides;	1	
	(b)		*Any six from:* Number of moles of AgCl in 14.1 cm^3 of 0.10 mol dm^{-3} = $\frac{14.1}{1000} \times 0.10 = 0.00141$ moles; 1 mole of AgCl ≡ 1 mole of NaCl; ∴ Number of moles in 25 cm^3 of seawater = 0.00141 (moles); ∴ Number of moles in 1000 cm^3 of seawater = $\frac{0.00141}{25} x\ 1000 = 0.564$; Concentration of chloride ions= 0.564 mol dm^{-3}; Molar mass of sodium chloride = 23 + 35.5 = 58.5 g mol^{-1} ∴ Concentration of salt (sodium chloride) = 0.564 x 58.5 = 33.0 g dm^{-3};	6	
8	(a)	(i)	*Any three from:* Iron(II) ions formed in the reaction between iron and concentrated sulfuric acid. Ammonium thiocyanate reacts with iron(III) Potassium manganate(VII) is oxidising agent. Oxidises iron(II) to iron(III)	3	

Question			Answer	Marks	Guidance
		(ii)	(thiocyanate) produces red colour/complex with iron(III); Colour is/needs to be <u>specific</u> to iron(III); Intensity of colour (must be) proportional to/linear relationship with iron(III) concentration (at least over a specific range).	3	**Accept** reference to Beer-Lambert Law for one of marks.
	(b)	**(i)**	There are 55.85 g of Fe in 482.20 g of $FeNH_4(SO_4)_2.12H_2O$; ∴ mass of ammonium iron(III) sulfate required to provide 20 mg of iron = $\frac{482.20}{55.85} \times 20\ \text{mg}$ = 172.68 mg;	1 1	

Question			Answer	Marks	Guidance
	(b)	(ii)		4	1 mark for axes 2 marks for plotting of points (1 mark if 3-4 points correct; 0 marks if <3 correct) 1 mark for appropriately drawn calibration curve.
		(iii)	9.1 mg dm^{-3};	1	Mark awarded only if answer within ± 0.1 mg dm^{-3} <u>on calibration curve drawn.</u>

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Question			Answer	Marks	Guidance
9	(a)		Use of silica gel TLC plates/silica gel as stationary phase in **2**. **Justification:** more likely to give better separation; Single spot used in **1** likely to be insufficient/spot built up in **2. Justification:** single spot of sample extracted from note unlikely to yield sufficient ink to give spots of appropriate density to be visible; **2** uses solvent *system*, 1 uses simple solvent. **Justification:** more complex solvent likely to give better separation/ method used in **2** published/known to work; In **2**, scans/permanent record of chromatograms made. **Justification:** enables permanent record to be kept/chromatogram could be required for evidence/spots will fade in **1**; In **1**, drawing around the spots destructive method of analysis/ in **2** drawing around spots of scans non-destructive/enables original chromatograms to be left intact. **Justification:** use of scans non-destructive /enables original chromatograms to be kept, undamaged. Designated distance moved by spot in **1** not recommended. . **Justification:** the extent of movement of the solvent will depend on physical conditions/precise distance irrelevant (but needs to be sufficient) as Rf value calculated.	4	One mark for each. Each aspect of the method must have an accompanying, correct/feasible justification for award of the mark. Maximum 4. Accept: No Risk assessment referred to in **1**. **Justification:** Risk Assessment required for all practical work.

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Question			Answer	Marks	Guidance
	(b)	**(i)**	Risk Assessment included in **1**/no Risk Assessment in **2**; Alternative to marking point 1: Risk Assessment included in **1**, but not necessary in a report, as this is taken for granted; Details of stationary phase/particle size of silica gel given in **2**; Use of pencil to indicate origin in **2**/unknown in **1**; Volumes of ethanol and water used not necessary in **1**/proportions sufficient, as in **2**; Technique/source of solvent system used referenced in **2**; Some of detail, e.g. dividing paper into sections, irrelevant in **1**; reference to ink samples vague; Justifications, e.g. building up of spot, given in **2**; Use of some incorrect science detail in **1**, e.g. use of word 'valid'/science behind separation of spots.	4	One mark for each. Maximum 4.
		(ii)	**2** heading is written as in scientific paper; **1** written in active language; But **1** written in present tense, as set of instructions/standard procedure/not appropriate for *report*; **2** written in past tense, as required by a report; But **2** in personal 'voice' (except for first sentence); A report should be passive, impersonal; Scientific paper normally written in prose, not numbered; Source of technique provided in **2** is good practice.	4	One mark for each. Maximum 4.

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